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CONTACTS

Phuoc X. Tran
Principal Investigator
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236
412-386-6024
phuoc.tran@netl.doe.gov

David K. Lyons
Extreme Drilling Team Leader
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-4379
k.david.lyons@netl.doe.gov

PARTNERS:

West Virginia University
Professor Rakesh Gupta

Carnegie Mellon University
Professor Lynn Walker

Nanofluids for Use as Ultra-Deep Drilling Fluids

Project Goal

This research is aimed at developing a new class of highly specialized drilling fluids that may have superior performance in high temperature drilling. Such research is applicable to high pressure high temperature drilling, which may be the key to unlocking large quantities of previously unrecoverable domestic fuel resources. If successful, the public will benefit from an increased fuel supply and the resulting price stability.

Background

Drilling fluids, commonly referred to as drilling muds, are an integral part of drilling oil and natural gas wells. A drilling fluid is typically pumped through the drill string and is subsequently introduced to the bottom of the bore hole as it squirts out of nozzles on the drill bit. This action not only cools and lubricates the drill bit, it also helps to convey rock debris and drill cuttings from the drilling area to the surface. The drilling fluids can also help prevent blowouts and wellbore cavings by creating hydrostatic pressure that stops formation fluids from entering the well prematurely.

For a drilling fluid to function in an effective manner, it must have the correct heat transfer and fluid-flow characteristics. Furthermore, it must be environmentally benign. Over the years, these requirements have been satisfied by both water-based and oil-based muds. Both contain some form of bentonite clay as well as a number of other additives. These modifiers may increase density, reduce corrosion, help disperse or flocculate particles, alter viscosity, and prevent bacterial growth. For deep-hole drilling, the temperatures and pressures can be prohibitively high, and the heat transfer demands on the drilling fluid can seem impossible to meet. In this situation, to engineer a viable drilling fluid, it is essential that the fluid's thermal properties be significantly enhanced.

ADDRESS

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street,
Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

Technical Approach

One way to engineer superior high temperature drilling fluids may be through the use of nanofluids. Among other possible applications, nanotechnology presents an opportunity for enhanced performance with respect to transport phenomena.

Nanofluids can be designed by adding nanosized particles in low volumetric fractions to a fluid. The nanoparticles improve the fluid's rheological, mechanical, optical, and thermal properties. Suspensions of nanosized particles may provide the following advantages: (1) Nanosized particles can have enhanced stability against sedimentation since surface forces easily balance the gravity force, and (2) Thermal, optical, mechanical, electrical, rheological, and magnetic properties of nanoparticles, which depend significantly on size and shape, can be customized during manufacture and are often superior to the base material.

Recent experiments have demonstrated that nanofluids have attractive properties for applications where heat transfer, drag reduction, binding ability for sand consolidation, gel formation, wettability alteration, and corrosive control is of interest. For heat transfer applications, the presence of these nanoparticles has been shown to increase the static thermal conductivity of the base fluid by as much as 160 percent with the addition of carbon nanotubes. The tribological performance of lubricating oils can also be significantly improved by dispersing carbon and metallic-based nanoparticles in these lubricants. Specifically, a reduction of the friction coefficient by over 25 percent was observed when adding nickel-based nanoparticles to lubricants.

Product Description

In collaboration with Professor Rakesh Gupta of West Virginia University and Professor Lynn Walker of Carnegie Mellon University, this project seeks to develop nanofluids for oil and gas applications. Of particular interest is designing a nanofluid with selected components to meet the increasingly demanding conditions of high temperature and pressure found in some deep wells and also to extend the reach of horizontal wells while avoiding harm to the environment.

This project seeks to demonstrate that nanofluids can be customized for superior suspension, pressure control, lubrication, and cooling characteristics. For suspension, this project will establish the nanofluid's capability to gel under specific conditions so that drill cuttings can be raised to the surface for disposal. Weighting agents will also be added to the fluid to increase its density and the pressure it exerts on the walls of the borehole. Under this project, the benefits of using drag-reducing polymer additives with nanoparticles to improve the drilling penetration rate, cleaning, lubrication, and cooling for the drill bit will also be quantified. Thus, the project's goal of establishing nanofluid's ability to significantly improve drilling speed and eliminate damage to the reservoir rock will be well established.